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the ascogonium is filled up by the loose tissue of the inner ramifications.

The ascogonium is divided by repeated partition into a number of asci, each of which in our species contains eight spores. According to the observations of several botanists, these spores are not developed before the next spring, so that the parasite is preserved through the winter by means of the peridia. In most species of *Erysiphe* these peridia are provided with hyaline appendages, some of which are of wonderful regularity and elegance of form, when seen under the microscope.

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FRESH-WATER ENTOMOSTRACA.

BY C. L. HERRICK.

THE collector of fresh-water specimens is constantly meeting unexpected forms, especially among the smaller organisms, and of these no order of animals furnishes a wider variety or more curious adaptations than the fresh-water Crustaceans embraced in the old group *Entomostraca*, which is by many authors at the present day subdivided into several orders of Crustacea, the name being retained for a single order. To the microscopist particularly they are available as a never-failing field for study, since a cup of water from almost any source will contain abundant material for a day's work.

The Entomostraca have specialized jaws, but the gnathites never exceed three pairs. The segments of the abdomen are devoid of appendages. The name was derived from two words, meaning insect and shell, by Otho F. Müller, and applied by him in his "*Entomostraca*" (1785) to the animals which had hitherto been all comprised in Linnæus' genus *Monoculus*, named from the supposition that they possess but one eye. This order has, generally speaking, been much neglected, and in America particularly it seems to have escaped attention. The members of this order are never large, and many are so small as to be with the greatest difficulty detected by the unassisted eye, yet from their great variety, wide range and immense number they assume a position of considerable importance in the animal kingdom.

Recent investigations instituted by Mr. S. A. Forbes, of the Illinois State Laboratory of Natural History, have emphasized the fact that the lowly animals play important parts in the economy of nature, he having found that these Crustaceans enter

largely into the diet of fish, even of the larger varieties. The larger portion of the Entomostraca, numerically at least, are vegetable feeders and live on the minute particles of matter floating in the water, which otherwise would tend to render our waters impure. The snails wipe clean the stones and water-plants, and the scavenger fishes remove the carrion, but it remains for minuter forms to search carefully each drop and remove the particles, microscopic even to the thousand eyes of the dragon-fly larva. Thus the *Sida* (Plate III) in swimming uses the branchial feet within the shell-valves, not only in taking the necessary air from the water, but, by creating a counter current between the bases of the feet, particles of food are constantly brought within reach of the jaws. In common with low forms of animals in general, the processes of reproduction are often curiously anomalous. Congress of the sexes is in many cases unnecessary for many generations, and some forms, especially the *Artemia*, or "brine shrimp," seem unusually susceptible to changes in their environment. Males are often produced only in certain seasons of the year or under certain climatic conditions.

In the *Daphnia* the females produce young by simple budding from the ovary, but in the winter the ovum is enclosed between the valves of the carapace, which is removed at each molt, and it is thus enabled to resist the severity of the cold season. Speaking of the molt it is interesting to note that every hair, even to the finest filament, throws off a sheath, so that the cast-off integument is a perfect copy of the animal from which it came. In the higher forms the eggs are carried during the later stages of embryonic existence in double or single sacs extending beneath or on either side of the abdomen. In the *Daphnia* and other forms enclosed in a carapace the animal is oviparous, and the young can be seen within the shell in a cavity above the abdomen for some time before they are sent out to paddle their own crystal canoe. They may be removed from the parent without inconvenience. In the larger sub-division, the *Lophyropoda*, the chief organs of locomotion are one or both pairs of antennæ, though natatorial feet are never wanting. The antennæ also serve as prehensile organs in the *Cyclopoidea*, while the feet throughout the whole legion have branchial filaments.

Every one who has used the microscope has met with some of these animals, and we will mention a few forms. If water, taken from the clear surface of a lake on a sunny day, be carefully ob-

served, often a delicate, transparent animal may be seen darting about in the vessel like a flash of light, or if the lake be shallow and abounds in water plants the related form represented in Plate I may be seen. As it springs from side to side of the jar it seems a living jewel, for the antennæ and abdomen are tipped with varying purple, and the body glows yellow and scarlet, and if the bright-red egg-mass be present it is a conspicuous object. Place it under the microscope with a low power and we can see the long flexible antennæ, and if it is a male the thickened basal joints can be seen terminating in a spine at the thirteenth, where the geniculating joint is situated. The antennules on either side of the head segment, which is distinct from the thorax in this species, and the stylets on the last joint of the abdomen, with their setæ, are noted—when the antennules begin to rotate like the paddles of a steamer, and bending the abdomen and immediately launching a powerful “kick” with the caudal setæ spread out, at the same time that the antennæ beat the water like oars in the hands of an expert, the animal springs out of sight. One instinctively looks for the fellow some yards away, but remembering that the whole animal is little over .06 of an inch long, we again adjust the slide and bring him into view.

More abundant than the *Diaptomus* and better known, is the *Cyclops*. Plate II represents a large species in which the hairs are greatly elongated, especially on the caudal setæ, the longest pair of which resemble feather dusters. The *Cyclops* has received more than its share of names, owing to the great difference between different stages of its existence. If we place a female *Cyclops* in a vial, in a few days little specks will be seen swimming about in the water, and the eggs will have disappeared. These specks prove to be the young of *Cyclops*, but so little like the parent that it requires much faith to believe they will ever assume its likeness. Instead of five pairs of feet there are but three, and as we watch the growth of the animal, these prove to be elementary antennæ and jaws, while the true feet bud out of segments not yet formed. Almost every pool furnishes another example of the *Cyclopoidea* in the *Canthocamptus* which resembles the *Cyclops* greatly, and goes through the same transformations. The body tapers gradually with no marked distinction between thorax and abdomen; the egg-sac too is under the abdomen, and has in connection with it a colorless tube.

Perhaps the next animal to attract our attention will be a crea-

ture clothed in defensive armor of crystal, with an ovoid helmet on the head, from beneath which protrude the secondary antennæ, which in this family are always the larger, and the chief organs of locomotion. On the back is a small shield-like plate from which are suspended the two plates enclosing the body. Under the scuta of the back the heart can be seen pulsating regularly, while just below it is the intestinal canal, usually green from the vegetable matter contained therein. The jaws are suspended from the upper part of the head and meet below, where their toothed, grinding edges are placed in opposition, so that all the food must necessarily pass between them to be comminuted. The existence of a median dorsal plate in *Daphnia* seems to have been overlooked, it will be readily found however in this species (*D. vetula*) by placing a specimen on a slide and allowing it to dry and then tilting it up.

The genus *Daphnia* is quite well represented in our waters, both in variety of species and abundance of specimens. The section of the genus separated by Dana and called *Ceriodaphnia* includes those members which have a cellularly reticulated shell, but this character does not seem constant in the closely allied smaller forms which it evidently ought to include, if indeed the same species may not embrace forms with both reticulate and non-reticulate shells.

One of the most interesting of all *Daphnia*-like species is *Sida*, Plate III. A species of *Sida* and also a new species of the allied genus *Daphnella* occurs in Minnesota waters. The body of *Sida* is highly transparent, rendering the study of the inner parts less difficult than in most of these animals. The movement of blood corpuscles in the head and the currents caused by the branchial feet (indicated by arrows in the drawing) can be readily traced.

The curious *Polyphemus* also is represented, an animal in which the body is much curved upon itself, and the last joint of the abdomen is greatly elongated and bears two long flagella. The single staring eye, occupying the whole of the head, is the most conspicuous organ, while the apparently undeveloped branchial feet at first suggest the young of some other species.

But the most curious of all these minute, shelled forms, is the single species of *Bosmina* (Plate IV), which constitutes the family Bosminidæ of Dana. The idea at once suggested is a strange burlesque on the elephant, though the animal is not by any means of elephantine proportions, being not two hundredths of an inch

in length. The superior antennæ, usually very small or nearly obsolete in the Daphnoidæ, are the longer, but they agree with those of other members of the tribe in having little motion or play. These many-jointed appendages constitute the trunk of our elephant, lying as they do in so close juxtaposition as to seem a single organ. The shell of *Bosmina* is tuberculate and partly, at least, reticulated with hexagonal cells. •

A group of smaller animals than any of the above is the old family *Lynceidæ* which is now included in the Daphnidæ. Many genera have been formed, but only one or two are founded on reliable generic characters. *Eurycercus* contains an animal nearly as large as *Daphnia*, but the remaining animals are small and they all agree in moving by a steady progressive motion rather than by successive bounds, which peculiarity is due to the shortness of the antennæ. The head is sharper in front and a little black spot beneath the eye, which is common to all Daphnidæ becomes in *Lynceus* and its allies as conspicuous as the eye itself. This spot is of unknown use but seems connected with the base of the antennæ.

There are representatives of two genera of the family *Cypridæ* to be found in every pool. These animals are enclosed in a shell which covers not only the body but the head also, so that the animal can withdraw entirely from view and close his shell about him like the mussel, which the shell much resembles in shape. The *Cypris* scurries about with an uncertain running motion, reminding one of the haste of an excited man, while the *Candona* loves the bottom. The inability to swim freely is due in *Candona* to the absence of the many setæ on the antennæ (the principal motary organs), which broaden these paddles in *Cypris*. In this sketch only a very few forms have been glanced at, and the legion *Phyllopoda* containing *Branchipus* and the "brine shrimp," has not been noticed, but objects enough to employ many a leisure day have been seen, any one of which might well repay weeks of study.

DESCRIPTION OF PLATES.¹

PLATE I.—*Diaptomus longicornis* Herrick, back view of female and side view of male; *a*, basal portion of male antennæ showing enlarged segments preceding geniculating joint.

PLATE II.—*Cyclops* sp. ? *a*, last pair of feet; 1, 2, 3, 4, 5, feet of *Cyclops quadricornis*; 6, inferior antennæ.

PLATE III.—*Sida crystallina* Straus. *a*, *b*, *c*, feet of first, second and last pairs; *d*, jaw; *e*, extremity of abdomen; *f*, superior antennæ.

PLATE IV.—1, *Bosmina longirostris*; *a*, portion of shell with superior antennæ; *b*, anterior antenna; 2, *Lynceus* sp. ?

¹ Used through the kindness of Prof. N. H. Winchell, Director of Minnesota Geological Survey.







